



(12) **United States Patent**
Brown

(10) **Patent No.:** **US 9,766,420 B2**
(45) **Date of Patent:** **Sep. 19, 2017**

(54) **APPARATUS AND METHOD FOR ABSORBING LASER ENERGY THAT FAILS TO COUPLE INTO THE CORE OF A LASER FIBER, AND FOR ABSORBING THE ENERGY THAT HAS BEEN TRANSMITTED TO THE CLADDING OF THE LASER**

(71) Applicant: **Joe Denton Brown**, Panama City, FL (US)

(72) Inventor: **Joe Denton Brown**, Panama City, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 152 days.

(21) Appl. No.: **14/217,927**

(22) Filed: **Mar. 18, 2014**

(65) **Prior Publication Data**
US 2014/0270661 A1 Sep. 18, 2014

Related U.S. Application Data
(60) Provisional application No. 61/788,238, filed on Mar. 15, 2013.

(51) **Int. Cl.**
G02B 6/24 (2006.01)
G02B 6/42 (2006.01)

(52) **U.S. Cl.**
CPC **G02B 6/4296** (2013.01); **G02B 6/243** (2013.01); **G02B 6/4206** (2013.01)

(58) **Field of Classification Search**
CPC G02B 6/243
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,912,362 A	10/1975	Hudson	
4,316,204 A *	2/1982	Inagaki	G02B 6/4202 257/432
4,474,429 A	10/1984	Yoldas et al.	
4,575,181 A	3/1986	Ishikawa	
4,678,273 A	7/1987	Vilhelmsson	
4,737,011 A	4/1988	Iri et al.	
4,762,385 A	8/1988	Fuse	
4,868,361 A *	9/1989	Chande	G02B 6/32 219/121.62
4,998,795 A *	3/1991	Bowen	G02B 6/243 385/139
5,097,524 A *	3/1992	Wasserman	G02B 6/32 385/73
5,101,457 A	3/1992	Blonder et al.	
5,132,079 A	7/1992	Stewart et al.	
5,179,610 A	1/1993	Milburn et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

JP 10246813 A * 9/1998

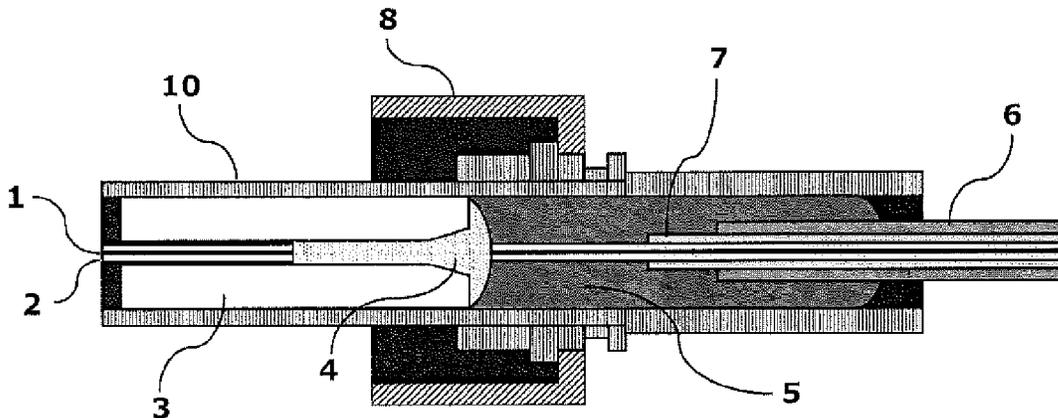
Primary Examiner — Charlie Y Peng

(74) *Attorney, Agent, or Firm* — Bacon & Thomas, PLLC

(57) **ABSTRACT**

A fiber optic connector for coupling focused radiant energy from a laser to a fiber optic conductor includes a quartz alignment ferrule that is fused mechanically and optically to the fiber's proximal end, either by an index matching first adhesive or by heat fusing the cladding to the ferrule without removing the cladding from the end of the fiber. The fiber and ferrule are attached to the fiber's proximal termination connector by a second adhesive with a high refractive index which absorbs errant radiant energy that has propagated in the fiber's cladding. The absorbed errant energy is dissipated by the connector assembly as it is converted to heat.

6 Claims, 1 Drawing Sheet



(56)

References Cited

U.S. PATENT DOCUMENTS

5,243,681	A	9/1993	Bowen et al.		6,488,414	B1	12/2002	Dawes et al.	
5,267,342	A *	11/1993	Takahashi	G02B 6/266	6,595,698	B2	7/2003	Gutierrez et al.	
				385/140	6,597,846	B1	7/2003	Fujii et al.	
5,291,570	A	3/1994	Filgas et al.		7,090,411	B2	8/2006	Brown	
5,452,392	A	9/1995	Baker et al.		7,918,612	B1 *	4/2011	Zhao	G02B 6/2553
5,490,227	A	2/1996	Tanabe et al.						385/95
5,619,602	A	4/1997	Sandstrom et al.		2002/0021870	A1	2/2002	Engstrand et al.	
5,668,902	A	9/1997	Kurata		2002/0071459	A1	6/2002	Malone et al.	
5,829,445	A	11/1998	Martin et al.		2003/0118283	A1	6/2003	Healy	
5,946,437	A	8/1999	Uchida et al.		2005/0191012	A1 *	9/2005	McGarvey	G02B 6/4212
6,154,596	A	11/2000	Ionov						385/88
6,167,177	A	12/2000	Sandstrom et al.		2007/0211999	A1 *	9/2007	Kobayashi	G02B 6/32
6,282,349	B1	8/2001	Griffin						385/79
6,317,550	B2	11/2001	Irie et al.		2008/0304799	A1 *	12/2008	Xie	C09J 5/06
6,332,721	B1	12/2001	Inokuchi						385/114
6,347,167	B1	2/2002	Hagelin		2008/0305255	A1 *	12/2008	Beauvais	G02B 6/08
6,477,295	B1	11/2002	Lang et al.						427/163.2
					2010/0014814	A1 *	1/2010	Taniguchi	G02B 6/4471
									385/77

* cited by examiner

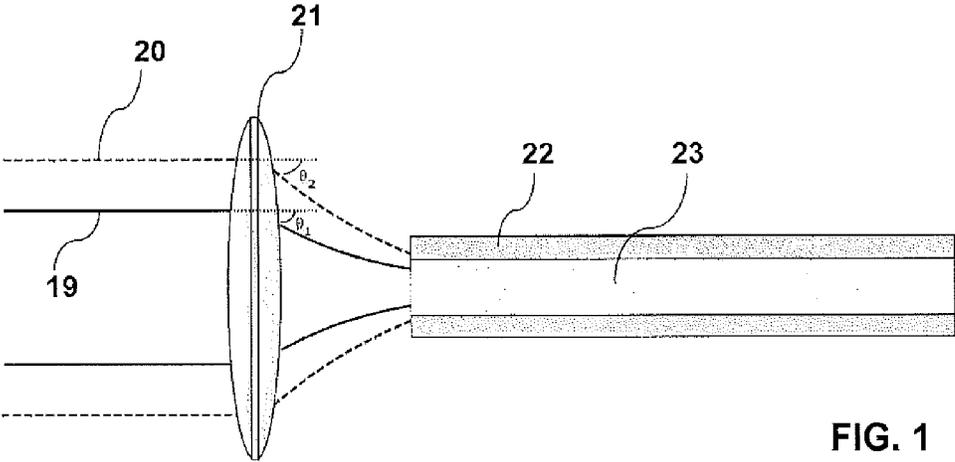


FIG. 1

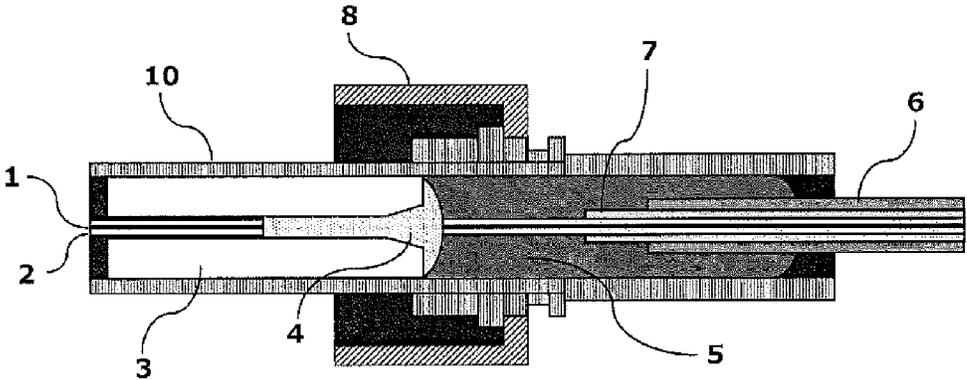


FIG. 2

APPARATUS AND METHOD FOR ABSORBING LASER ENERGY THAT FAILS TO COUPLE INTO THE CORE OF A LASER FIBER, AND FOR ABSORBING THE ENERGY THAT HAS BEEN TRANSMITTED TO THE CLADDING OF THE LASER

This application claims the benefit of U.S. provisional patent application Ser. No. 61/788,238, filed Mar. 15, 2013, and incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a fiber optic connector and connector system or arrangement for coupling focused radiant energy from a laser to a fiber optic conductor.

2. Description of Related Art

The invention provides an improvement to the connector arrangements disclosed in the Inventor's U.S. Pat. Nos. 5,179,610 and 7,090,411, incorporated by reference herein. In the connectors disclosed in the cited patents, radiation that fails to couple with a small core fiber and radiation which couples with higher order propagation modes is absorbed by the connector or surrounding structures. The improvement permits the use of a fiber with full cladding, thereby making the fiber termination more rugged and simplifying manufacturability.

SUMMARY OF THE INVENTION

A fiber optic connector for coupling focused radiant energy from a laser to a fiber optic conductor includes a quartz alignment ferrule that is fused mechanically and optically to the fiber's proximal end, either by an index matching first adhesive or by heat fusing the cladding to the ferrule without removing the cladding from the end of the fiber. The fiber and ferrule are attached to the fiber's proximal termination connector by an adhesive with a high refractive index which absorbs errant radiant energy that has propagated in the fiber's cladding. The absorbed errant energy is dissipated by the connector assembly as it is converted to heat.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic depiction showing the effects of thermal lensing on coupling of a focused laser beam to the core and cladding of the fiber.

FIG. 2 is a cross-sectional side view of proximal terminal connector constructed in accordance with the principles of a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, a laser beam 19 is focused into the fiber core 23 by the laser's focusing lens 21 with a half angle of acceptance (θ_1). However, due to thermal lensing, an expanded beam 20 is focused into both the fiber core 23 and cladding 22 with a half angle of acceptance (θ_2). The present invention uses refractive index matching adhesives to pro-

vide a path for dissipation of the energy in the cladding to a heat sink in the form of a ferrule and/or structures in contact with the ferrule.

As shown in FIG. 2, the termination arrangement of a preferred embodiment of the invention is included in a proximal termination connector 10 and threaded nut 8, although the illustrated connector and nut configuration should not be taken as limiting since the invention can be applied to a variety of termination connectors, including ones without nuts.

The fiber inside the connector consists of a fiber core 1, cladding 2, coating 7, and buffer 6. The fiber is fused to the quartz ferrule 3 by a refractive index matching first adhesive 4 or by heat fusing the cladding 2 to the ferrule 3 without removing the cladding from the end of the fiber, and the fiber and ferrule are secured in the connector by a high refractive index second adhesive 5, thereby providing a dissipation path for energy that has coupled to the cladding 2 rather than to the core 1 of the fiber.

Having thus described a preferred embodiment of the invention in connection with the accompanying drawings, it will be appreciated that the invention is not to be limited to the specific embodiments or variations disclosed.

I claim:

1. A fiber optic connector arrangement for coupling focused radiant energy from a laser to a fiber optic conductor, the fiber optic conductor including a core and cladding, comprising:
 - an alignment ferrule; and
 - an index matching first adhesive for mechanically and optically fusing the alignment ferrule to a proximal end of the fiber optic conductor,
 wherein the fiber optic conductor and ferrule are attached to a connector by a second adhesive with a high refractive index so as to absorb errant radiant energy that has propagated in the fiber optic conductor's cladding.
2. A fiber optic connector arrangement as claimed in claim 1, wherein the ferrule is a quartz alignment ferrule.
3. A fiber optic connector arrangement as claimed in claim 1, wherein the connector is a proximal termination connector with a coupling nut.
4. A fiber optic connector arrangement for coupling focused radiant energy from a laser to a fiber optic conductor, the fiber optic conductor including a core and cladding, comprising:
 - an alignment ferrule, wherein the cladding of the fiber optic conductor is heat fused to the ferrule without removing the cladding from the end of the fiber optic conductor; and
 - an adhesive for attaching the fiber optic conductor and ferrule to a connector, wherein the adhesive has a high refractive index so as to absorb errant radiant energy that has propagated in the fiber optic conductor's cladding.
5. A fiber optic connector arrangement as claimed in claim 4, wherein the ferrule is a quartz alignment ferrule.
6. A fiber optic connector arrangement as claimed in claim 4, wherein the connector is a proximal termination connector with a coupling nut.

* * * * *